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RADAR DIRECTION-FINDING TECHNIQUE USING SPIRAL ANTENNAS
AFRL's New Technique Will Significantly Aid Airborne Operations

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14. ABSTRACT

AFRL scientists demonstrated a new radar direction-finding (DF) technique that uses a four-arm spiral antenna. To validate the technique, they used the actual wideband measurements of a four-arm spiral antenna and its associated modeformer to assess and verify the antenna's azimuth angle estimation capability.

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Radar Direction-Finding Technique Using Spiral Antennas

AFRL's new technique will significantly aid airborne operations.

AFRL scientists demonstrated a new radar direction-finding (DF) technique that uses a four-arm spiral antenna. To validate the technique, they used the actual wideband measurements of a four-arm spiral antenna and its associated modeformer to assess and verify the antenna's azimuth angle estimation capability.1

The frequency-independent characteristics of spiral antennas make them an attractive solution for deriving angle-of-arrival (AoA) estimates. Their weight, size, power requirements, and field-of-vision properties further enhance their appeal— especially for airborne DF.2 In using these antennas, scientists combine the terminal outputs of the multiple arms into a Butler matrix modeformer and then derive the angle information from the outputs of the modeformer. Comparison of the signal's phases at the modeformer outputs produces an estimate of the incoming signal's azimuth angle, while comparison of the signal's magnitudes at the modeformer outputs produces an estimate of the incoming signal's elevation angle. Figure 1 illustrates the geometry of a spiral antenna and an incoming signal, where "φ" indicates azimuth and "θ" is elevation.
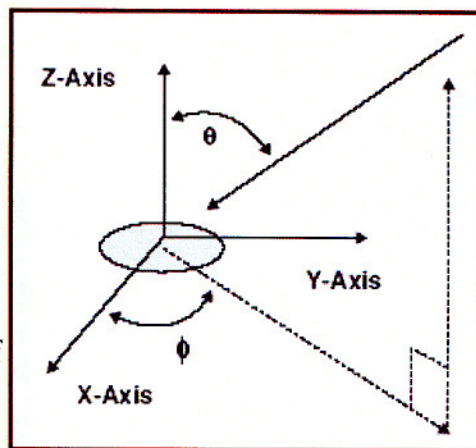

Figure 1. Incoming signal geometry of a multiarm spiral antenna

Using this comparison-based DF technique with a four-arm spiral antenna and corresponding mode— former hardware provides AoA estimates as accurate as those obtained using two single-mode antennas separated by a half-wave (one-half wavelength) interferometer. Further, the use of a four-arm spiral antenna— as opposed to a half-wave interferometer— enables the bandwidth of AoA estimates to remain constant over the entire range of frequencies for which the spiral antenna is devised.

Researchers performed all measurements for this effort in AFRL's Radiation and Scattering Compact Antenna Laboratory (RASCAL), which comprises a compact far-field range for measuring smaller-sized antenna aperture patterns.3 In order to obtain accurate data from each spiral antenna, researchers used a phasestationary test body for all four-arm spiral measurements (see Figure 2 on previous page). The phase-stationary test body is a requirement for closing the distance between a conformal antenna host surface and the designer's infinite ground plane model. The almond-shaped test body employed for this experiment is a documented, proven, and patented device for obtaining high-performance antenna measurements.4

Figure 2. Actual test body in RASCAL compact range

After performing phase compensation to accurately calibrate modal phase outputs, researchers proceeded to azimuth angle estimation, conducting multiple Monte Carlo experiments using the actual azimuth measurement data collected in the RASCAL compact range. Signal-to-noise ratio, frequency, and elevation angle represented the three independent variables considered for these experiments. The results revealed consistency in the mean of 360° azimuth estimates (see Figure 3 on previous page) over numerous experiment iterations and demonstrated the broadband capabilities of the multimode spiral antenna for azimuth angle estimation.5

Mr. Joshua Radcliffe and Dr. Krishna Pasala (University of Dayton), of the Air Force Research Laboratory's **Sensors Directorate**, *wrote this article. For more information, contact TECH CONNECT at (800) 203-6451 or place a request at* http://www.afrl.af.mil/techconn_index.asp. *Reference document SN-H-05-04.*

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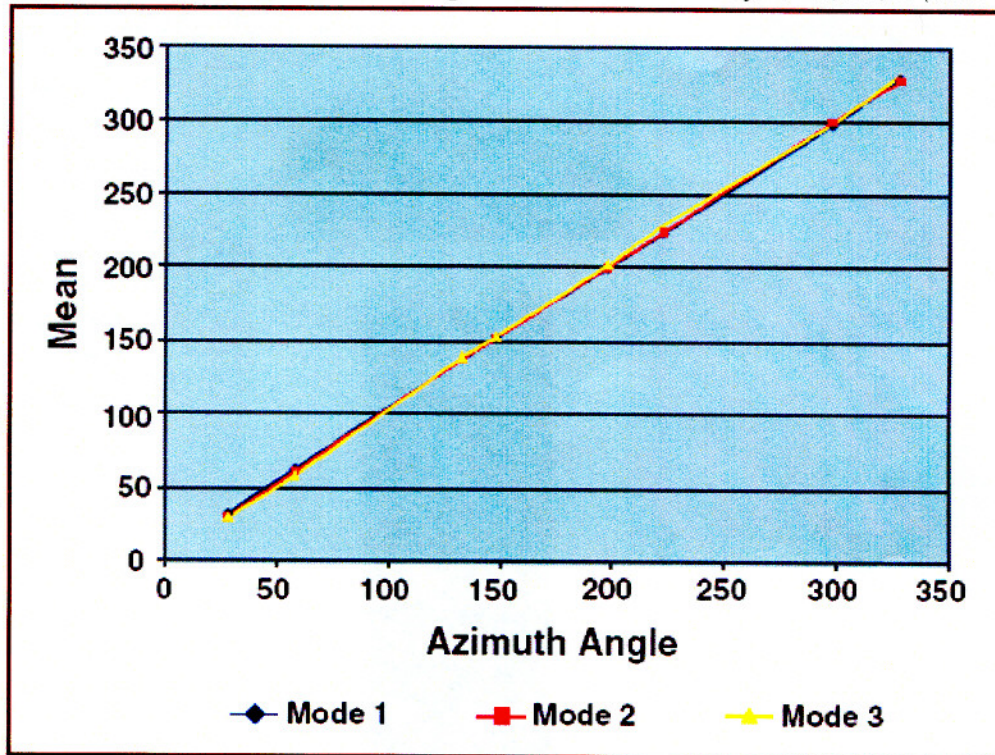3 Radcliffe, J. S. "RASCAL Facility." AFRL Technology Horizons®, vol 7, no 1 (Feb 06): 18-19.

Figure 3. Mean of azimuth angle estimates for 4 GHz

4 Shamansky, H., et al. "A Phase-Stationary High-Performance Antenna Test Body." AMTA Annual Symposium Proceedings, 1995.

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